Multiresolutional Representation and Behavior Generation: How Do They Affect the Performance of Intelligent Systems

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Abstract

In this tutorial, an outline of the theory of intelligent systems is presented as a sequence of the following issues. The term "Intelligent Systems" has a meaning implied by our usage of it within the domain related to the formidable phenomenon of Life and functioning of Living Creatures. However, neither for living creatures not for engineering devices this term cannot be presented through the list of functional properties and/or design specifications. Our theory is based upon two phenomena that should be considered in their interconnection: a) the existence of an Elementary Loop of Functioning (ELF) in all cases of systems with intelligence, and b) formation of Multiple Levels of Resolution (MR) as soon as ELF emerges. MR levels develop because of the mechanisms of joint Generalization and Instantiation due to the processes of grouping, focusing attention and combinatorial search (GFACS). The latter are explanatory for the subsystems of Learning/Imagining/Planning that are characteristic of all intelligent systems. This paper introduces the variety of mechanisms of disambiguation that pertain to functioning of intelligent systems.On the other hand, MR and ELF together lead to the development of Heterarchical Architectures. The above concepts are explanatory of the kinds of intelligence that are observed in reality and suggest how to test the performance of intelligent systems and what are the metrics that could be recommended.

1. Intelligent Systems: Invoking the Design Specifications

Multiple characterizations of intelligence and intelligent systems have been collected in [1, 2]. The meaning of the terms are instilled by our associations with human beings, or even with living creature in general. The desire to create similar properties in constructed systems has determined the tendency to *anthropomorphize* both faculties and functions gadgets and systems belonging to various domains of application. This starts with categorizing objects into ACTORS, or agents that produce changes in the state of the world by developing ACTIONS, and the OBJECTS OF ACTIONS, i. e. the objects upon which the ACTIONS are applied. ACTIONS are the descriptions of activities developed by the ACTORS.

Yet, this does not give an opportunity to exhaustively, or even simply adequately describe intelligent systems in the terms of design specifications. One reason for this is that specifications are never complete. They are never fully appreciated and understood either.

Example 1: Spot Welding Robot. These are the features that are frequently claimed for it:

- It has Basic Intelligence. The meaning of this assertion does not extend beyond simple salesman decorative phrase. Even in the universities, courses on binary logic and circuits with switches are called "Introduction to Intelligent Systems". Even a wall switch can be characterized as a carrier of intelligence of making the light "on" or "off".
- Programmed for specific task. Certainly the number of programmed functions is very limited in a robot. Yet, probably, any number of functions being pre-programmed is an evidence of intelligence (the one of the designer, the ability of the system to store information ("memorize things"). Memorization what should be done in a response to a particular command is considered a certain level of animal intelligence.
- No operator is needed. When you see this statement in the list of welding robot specifications, you should raise a question what is the quality of the results of welding comparing with welding by a human operator. Even now, the feedback system are

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limited in their ability to eliminate the need in a good professional welder.

- Can only perform repetitive tasks without deviation from programmed parameters. No doubt about it: one should realize that this statement is rather a disclaimer than a claim of intelligent functioning.

Example 2: Mars Sojourner. The word "Mars" evokes associations of the machines of the future. However, no real faculties of intelligence could be listed (the welding robot was substantially "smarter").

- Remote Control – should not be considered a property of intelligence because by extending the distance between the operator and the machine we do not make the machine smarter, or more sophisticated, or capable of dealing with unexpected situations, or interpret illegible commands, etc.
- Light elements of autonomy. The specifications do not expand on this concept ("autonomy"). Probably, the ability to provide a feedback control can be (arguably) interpreted as elements of autonomy.
- Can Perform a variety of maneuvers (limited). This property seems to be similar to having preprogrammed functions.
- A particular maneuver is performed independently. All available maneuvers should be discussed and evaluated separately. Indeed, the maneuver of "turning right" and the maneuver "make a K-turn in a particular tight space" require different level of intelligence: from zero up to the substantial degree of perception-based autonomy.
- Not capable of deciding what to do next (no planning). Absence of "planning" in most cases means no intelligence.
- Problem:10 minute communication Lag Between earth and Mars (and probably, the guy does not know what to do next and does not dare to think about it!)

Example 3: Bomb Disposal Robot. This is another case of the device for remote performance (extention of capabilities of a human operator). These robots are called "intelligent" because of the importance of their mission, and also because the should be able to reproduce human movements with absolutely no mistakes.

- Remote Operation with high accuracy create the aura of respect. If the "increase in accuracy" could be claimed, this would be a very conspicuous demonstration of an intelligence.
- Requires very skilled operator. This is a claim of intelligence of the operator. However, it is an important assertion that this remote control device cannot substantially detriment the skills of the operator.
- Incapable of acting on its own (does not have any intelligence at all). This is related to most of the remote controlled devices.

Example 4. Intelligent Network. An example of the communication system with intelligent systems as the nodes of the network is shown in Figures 6 and 7 of [3]. The description of the communication network containing intelligent systems demonstrates that a) the concepts of closure within the intelligent node, b) multiresolutional distribution of information, and c) heterarchical networks are characteristic for this example. This was not observed in the Examples 1 through 3. Thus, one might assume that our dissatisfaction with Examples 1 through 3 was based upon an existing difference between classes of systems as far as the level of their intelligence is concerned.

In our further discussion, we will call all objects including ACTORS and OBJECTS OF ACTION by the term entity. The ACTION can be characterized and represented as a Discrete Event (DE). The concrete choice of the phenomena and objects as actors, DE and objects of action is determined by a combination of temporal and spatial resolution characteristic for a particular level. The structure of the object at a particular level of resolution is shown in Figure 1. The structure of the DE for a level of resolution can be introduced in a similar way. The structure is a recursive one because each "*part*" can be substituted by a similar structure, and the representation of objects will evolve into the high resolution domain. Similar evolution is possible into the low resolution domain: Figure 1 should be used for representing each of the *parents*.

Thinking about constructed intelligent systems brings the researcher to the ideas of autonomous robots that are capable of understanding incomplete assignments (commands), apply the general intention of the command to the

particular situation at hand, etc. How about telling the robot: "Go to the window and alert me if something unexpected appears in the street?.." Apparently, this is the performance of an intelligent system that is justifiably expected in a market of intelligent systems soon enough. This popular demand is not far from its possible satisfaction. The designer's options include on-line or off-line learning from experience and using multiple tabulated alternatives together with efficient decision making procedures.

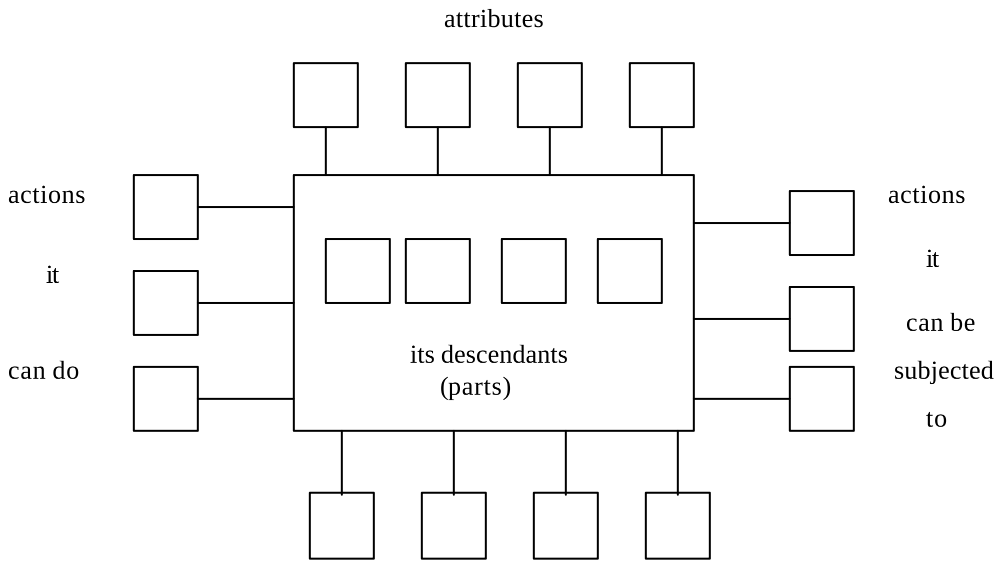

Figure 1. Structure of the Object

2. E L F: Elementary Loop of Functioning

***The Law of Closure*.** Closure is the foremost property of Intelligent Systems (IS) and should be satisfied at all levels of its Architectures. The Elementary Loop of Functioning (ELF) of IS can be defined at each level of the IS and should be consistently closed in each communication link between the subsystems of ELF as described in [1, 2, 4]. Unlike the classical "feedback loop," the loop of ELF is not focused upon the deviation from the goal: it is focused upon the goal. As soon as we can explain for a particular scene and/or for a particular situation who are the ACTORS, what ACTIONS do they develop, and upon which OBJECTS OF ACTION their actions are applied – the Elementary Loop of Functioning has been found. In Figure 2. The subsystems of this loop determine basic properties of the intelligent system.

SENSORS (S) are characterized by their ultimate resolution and their scope of the information acquisition per unit of time. In SENSORY PROCESSING (SP), the primary clustering is performed (together with organization and bringing all available data to the total correspondence), and the resolution of clustered entities is evaluated. The WORLD MODEL,WM (or Knowledge Representation Repository, KRR) unifies the recently arrived and the earlier stored information within one model of representation that determines values of resolution for its subsets. Mapping the couples [goal, world model] into the sets of output commands is performed by BEHAVIOR GENERATION (BG) for the multiplicity of available ACTUATORS (A), actually maps the resolutions of the WORLD MODEL into the resolutions of output trajectory.

Closure of all these units (…➔W➔S➔SP➔WM➔BG➔A➔W➔…) is determined by the design of the system and the learning process of defining the languages of the ELF subsystems.

- The First Fundamental Property of Intelligent Systems Architectures (the property of the existence of intelligence), can be visualized in the law of ***forming the loop of closure***.

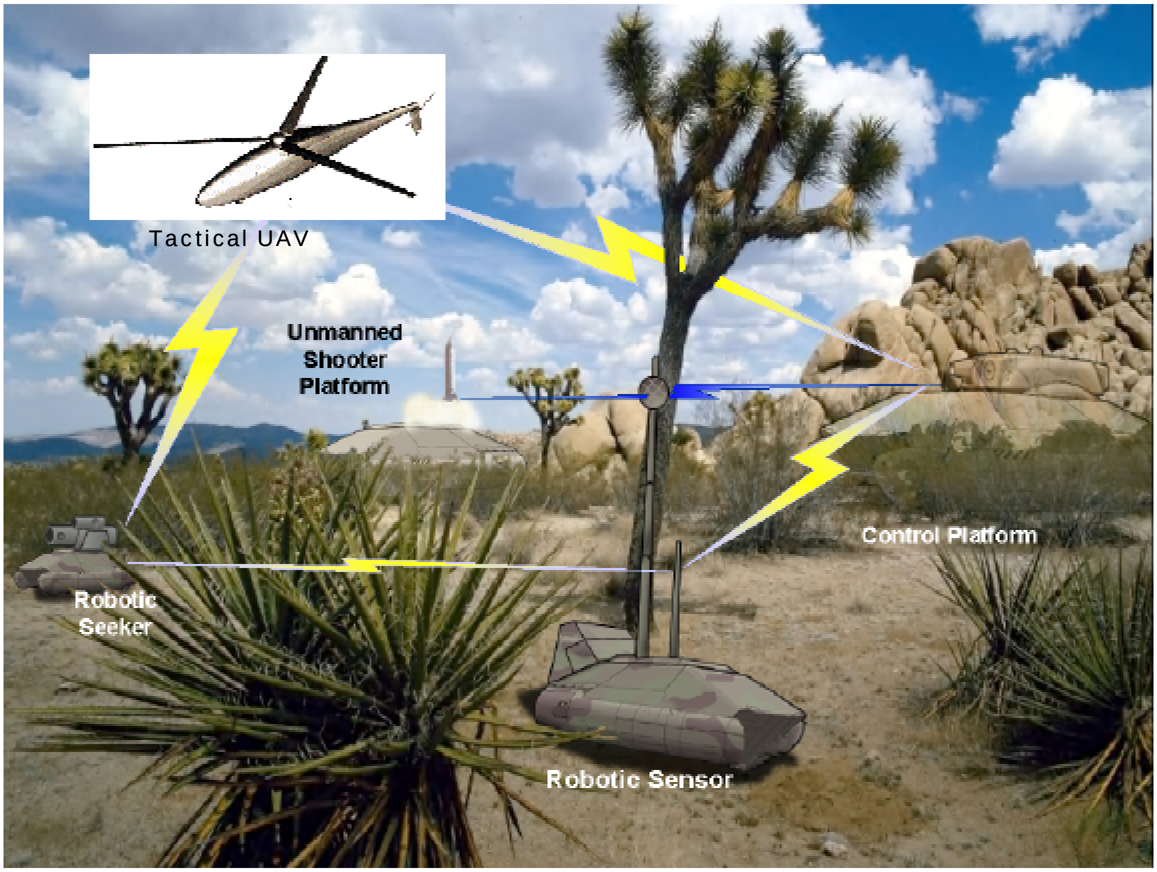

Figure 2. Design of a military situation (source: DARPA)

Closure is satisfied and the *consistency* of ELF holds when the unity of language (vocabulary and grammar) holds for each communication link between every pair of ELF subsystems.

- No matter what is the nature of the intelligent system, no matter what is the object-oriented domain under consideration, **the structure of closure is always the same.**

Statistical Closure. Functioning of the ELF cannot be impeccable because of noise and disturbances arriving from the external world and because of the errors of computations within ELF. Thus, as a result of mistakes, the property of closure is not satisfied impeccably. Thus, we should expect that only statistical closure can be satisfied reliably. The phenomenon of the time span between the "cause" and the "effect" is observed for both the closure of "in-level" functioning and the closure that is demonstrated for reduction of resolution when the information is integrated bottom-up. The following observations are important for interpreting reported information on the events in a system:

- The existence of closure at the lower (generalized) levels of resolution was considered a surprise and was even given a special term: "statistical closure" [5].

Now, it would not be difficult to understand that ***every closure is a statistical closure*** including closure reflected by the "in-level" functioning as well as closure obtained as a result of generalization of information tp the lower level of resolution.

- Obviously, there are no cause-effect events that happen simultaneously: if absence of the time span was reported, there is no basis for considering particular events of having "cause→effect" relationships.
- The time of any event is an ***integration*** of realistic or statistical results ***of the potential multiple experiments.*** This should be realized while determining whether the events are separated by a time span.

These observations can often protect us from a misinterpretation, but not in all cases. Even consistent ELFs are capable of generating

misinterpretations related to causality. Example: it is known that 80% of patients with hip fracture die within a year not because of hip fracture complications but because they had another condition that brought them to fall (they had it prior to the hip fracture). Obviously, many of these misinterpretations ascend to the formation of the languages for the subsystems of an ELF. The *purpose* may not always be explicitly represented but it can always be explicated as the analysis of *causes*. Although, etiological analysis (contemplation of causes) is always presumed, it is seldom performed.

3. Levels of Resolution and Intentionality: Multiresolutional Analysis

We need to reduce the complexity of computations by grouping similar units (entities) into the larger formation that can satisfy the definition of an entity, too. The words "we need" are italicized because the issue of "need" is a critical one in the very emergence of this phenomenon: multiple levels of resolution. The *needed* entity is a "lower resolution" entity: the details of high resolution are unified together under a specific objective (representing the intentionality). The totality of lower resolution entities forms a "lower resolution world" of representation, or the "lower resolution level." Within the "scope of the world" considered at the higher resolution, we will have much smaller total number of entities, and for the same computational power, the scope of the world or the efficiency of computation can be substantially increased. This is why we are searching for the lower resolution entities and producing generalizations. Thus: the limitations in processing speed, memory size, and sensor resolution spur our creativity up.

There are numerous ways of representing information at a level of resolution. The most wide spread method presumes performing a sequence of the following steps as *the Algorithm of Information Organization*:

Step 1 (S1). Hypothesizing the entities within particular boundaries separating them from the background and other hypothesized entities. More than one hypothesis for an entity is expected to be introduced (a list of hypotheses is supposed to be formed and maintained)

Step 2. Searching for confirmation of the hypotheses {H} of Step 1 (HS1) and evaluation of current probabilities of HS1 being the "truth,"

Step 3. Hypothesizing a meanings of the hypothesized entities $[HS1_i \rightarrow M_i]$; call this couple "a meaningful entity." More than one hypothesis for the meaning is expected to be introduced (a list of hypotheses is supposed to be formed and maintained).

Step 4. For each hypothesized meaningful entity $[HS1_i \rightarrow M_i]$ determine its plausible goal (objective)
$\{[HS1_i \rightarrow M_i]$ under the goal $G\}$. This is associated with the ability to hypothesize (and verify) the "cause→effect" couples and hypothesize a purpose of events (etiological analysis).

Step 5. For each $\{[HS1_i \rightarrow M_i]$ under the goal $G\}$ determine its relationships with other meaningful entities of the "scene," going back to Steps 1 and 2; considering different hypotheses; converging to the maximum values of probabilities evaluation.

Step 6. Constructing the entity-relationship network for the scene (ERN_j)

Step 7. Search within ERN for islands-candidates for generalization into the entities of lower resolution. As the candidates has been determined consider them hypotheses of entities with particular boundaries similar to those mentioned in **Step 1** and **GO to Step 2**. If no new islands emerged, EXIT from the recursive search from entities and **GO to Step 8**.

Step 8. Submit the hierarchy of ERNs to World Model.

This sequence of steps can be applied to any type of information representation including visual, audio, verbal, etc. The sequence can be illustrated by using a set of multiresolutional images, for example, from [6].

One can see that some Logic is presumed to be introduced for dealing with the multiresolutional information at hand. Unlike the standard propositional and predicate calculi, this logic has to predicate various situations and related sub-situations by their goals (purposes, objectives) being important factors in the process of inference. We believe that the Intensional Logic of Entities (Objects) can be proposed for using in the system with multiresolutional ELFs. An important role is here allocated with the concept of alternative worlds (possible situations or possible worlds). This can be considered an extension of the known notion of the "world model". This allows looking for alternatives to

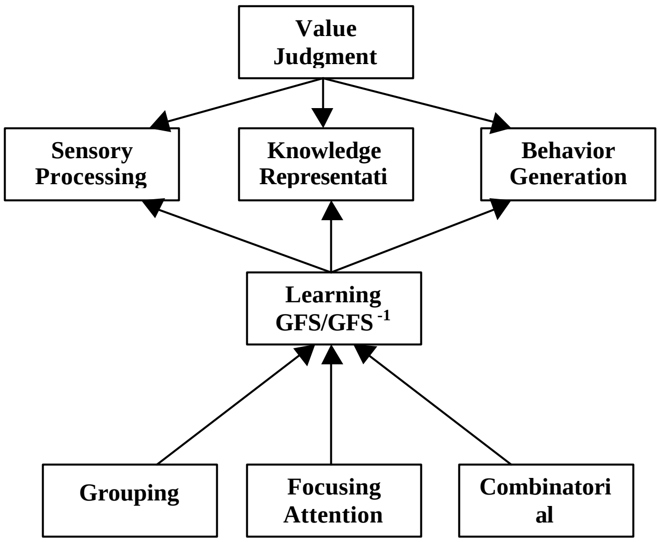

Figure 3. Combinatorics of GFACS/GFACS-1 functioning

the actual course of events in the world. On the other hand, adding the hypothesized purposes makes all statements *intentional* as well.

Intensional logic with explicated intentionality should become a basis for the introductory Multiresolutional Analysis (MA). The latter can be defined as constructing the representation and using it for the purposes of decision making. Using computational algorithms leads to taking advantage of representing the World as a set of sub-Worlds each with its individual scope and the level of detail.

The possibility and the need for MA is looming as can be seen from D. Dennett's Multiresolutional Stance where the property of considering many levels of resolution is being associated with intentionality:

> "To explain the intentionality of a system, we simply have to decompose the system into many, slightly less intelligent, subsystems. These subsystems can also be broken down into many more less intelligent subsystems. We can continue to break up these larger systems until eventually we find ourselves looking at individual neurons" [7].

Multiresolutional analysis boils down to purposeful development of multiresolutional heterarchies which

*protects us from paradoxes [e.g. of the pitfalls of self-referencing]
*allows for interlevel disambiguation
*determines true ontologies and definitions
*outlines symbol grounding activities

4. GFACS and GFACS^{-1}: Generalization and Instantiation by Using GFACS Operator

Both GFACS and GFACS-1 consist of the simpler procedures that are called "grouping", "focusing attention", and "combinatorial search". Most of the procedures that are being applied for computer vision and intelligent control systems are based upon the GFACS set of procedures. Examples: "Windowing" broadly aplied for selection of the representative part of the information set, is actually *searching* (combinatorially), CS. Masking irrelevant sub-entities is actually *focusing attention*, FA. On the other hand, the same "Windowing" contains a substantial component of "masking" and thus, can be interpreted as "focusing attention", FA in additional to searching combinatorially, CS. All algorithms of "clustering" can justifiably be interpreted as "grouping", G. Algorithms of "filtering" are "focusing attention", FA. Hypothesizing the entity in an image always includes all of the above: G, FA, CS.

4.1 Level-to-level Transformation: Generalizing by GFACS

The Algorithm of Information Organization presented above (see Section 3) contains the operator of generalization in its **Step 7**. It can be further decomposed into the following sub-steps:

7.1 Search within ERN for islands-candidates for generalization into the entities of lower resolution. This search will include forming tentative combinations of high resolution entities into sub-entities that allow for a consistent interpretation. Logic of this "combinatorial search" includes "focusing attention" upon the results of tentative "grouping" and determine properties of these tentative groups and their relations with each other.

7.2 As the candidates has been determined, finalize "grouping" and label the groups.

7.3 Consider these groups to be hypotheses of entities and analyze the corresponding ELFs.

Generalization is finished after the newly synthesized entity became a part of corresponding ERNs and ELFs.

4.2 Instantiations: GFACS^{-1}

In the inverse procedure, the system is searching for the plausible decomposition of a legitimate entity (that received a status of "group" as a result of prior "generalization"). Usually, this requires for performing several re-hypothesizing the components of entities and grouping them again to check whether they retain the meaning declared earlier. This features the following steps of instantiation: the hypotheses of instantiations are arriving from the adjacent level of lower resolution after hypothesizing (i.e. are arriving from "above") and should be verified by repeating the procedure of "grouping" at the level of higher resolution (i.e. "below"). In Figure 3, the richness of procedural capabilities is illustrated that is achieved in a single ELF as a result of GFACS/CFACS^{-1} functioning. From Figure 3, one can see that the generalization/instantiation couple can be considered a core of unsupervised learning [1]. This determines the need is a special logic of inference.

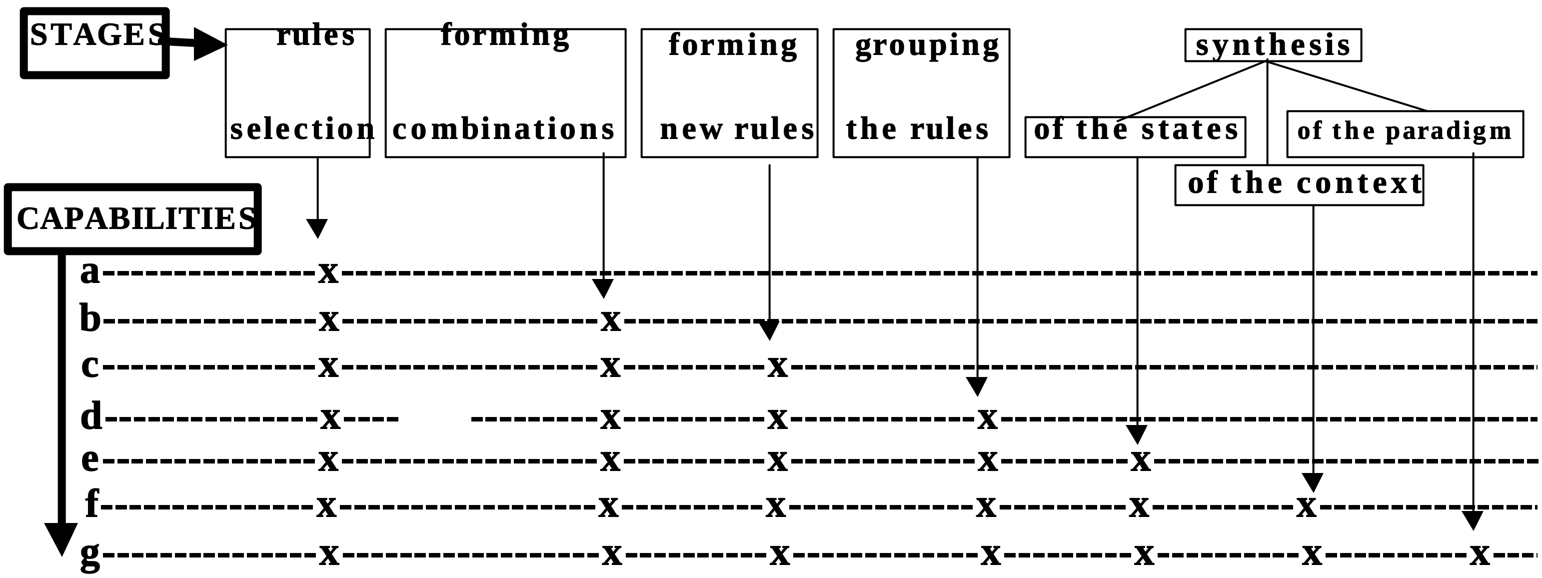

Figure 4. Logical Properties Acquired at Different Stages of the Intelligence Development

4.3 Advanced Logic Induced by Generalization/Instantiation

Indeed, the standard set of the inference tools taken from the arsenal of Propositional Calculus and Predicate Calculus of the 1st Order builds the inference processes primarily based on the undeniable conclusions that can be made from having a set of properties known for a particular class (ergo: belonging to this class), or conclusions that can be made from the fact of belonging to a particular class (ergo: having properties characteristic for this class). Forming new objects and/or new classes, growth of object and events hierarchies are new phenomena in the domain of inference. Even more powerful are the capabilities linked with new abilities to infer the purpose, construct hierarchies of goals, imply cause-effect relationships. In Figure 4, it is demonstrated that the introduction of logical capabilities and the enhancement of the ability to infer emerges as a result of incorporation of computational capabilities based upon equipping the system gradually by the new computational tools: including rule selection, forming combinations of rules, forming new rules (as a result of learning), grouping the ryles, forming combinations of the states and the context.

Unlike the symbolic logic that is supposed to be precise, free of ambiguity and clear in structure, the logic of multiresolutional system of ERN is limited in precision by the demands for ***associative disambiguation*** (see Section 7) that spreads into the adjacent levels of resolution (no "*logical atomism*" is presumed).

4.4 Learning, Imagining, and Planning: The Tools and Skills of Anticipation

Since the etiology enters the discussion, it would not be an exaggeration to state that the GFACS/CFACS^{-1} couples induce the knowledge of a Future, give the intelligent system the skill of anticipation. Thus, learning invokes imagining "what if" and various alternatives are being simulated to exercise the alternatives for estimating the Future and planning the Future as it was described and illustrated in [8] (see Figure 5). Actually, all types of intelligent processing of information are about the Future.

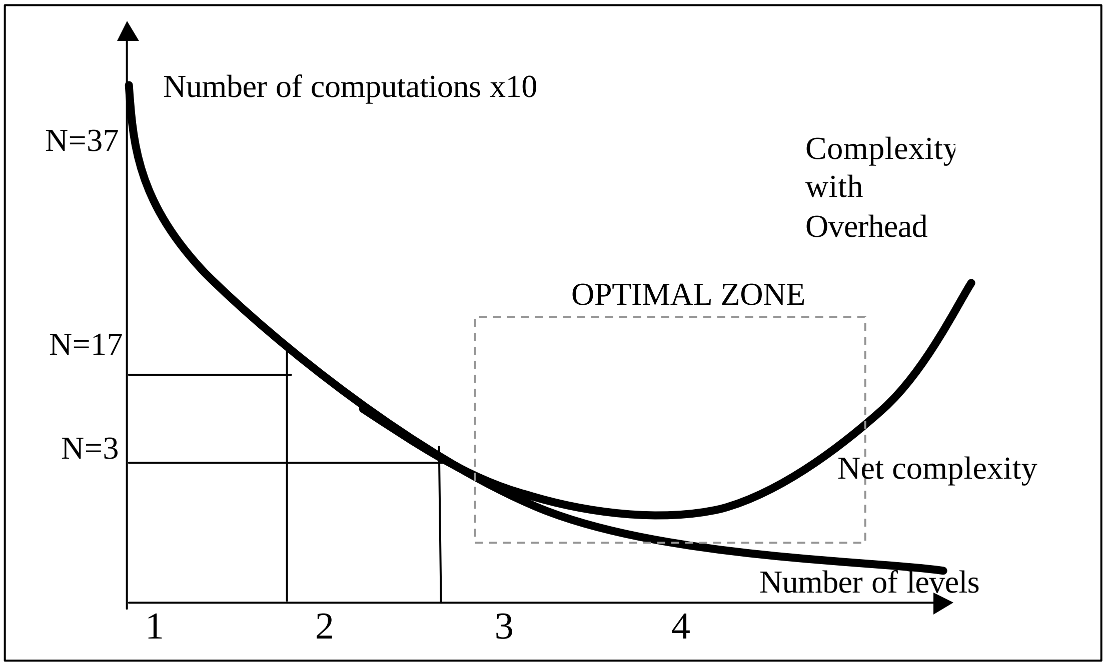

Figure 5. Computational complexity is reduced by introduction of additional levels of resolution

5. Intelligent Architectures and Kinds of Intelligence They Embody

5.1 More About Multiresolutional Combinatorial Search

Complexity in Multiscale Decision Support System depends on the number of levels of resolution. In Figure 5 the linkage between computational complexity and the number of levels of resolution is shown for a problem of path planning. The Example with DEMOIII would clarify how the levels of resolution differ in their parameters. Actually, lowering the resolution bottom up fits within the hierarchy of command, increase of the planning horizon and re-planning interval helps to bring the best properties of the system to a realization. The following are 4-D/RCS specifications for the planning horizon, re-planning interval, and reaction latency at all seven levels (see the table).

5.2 Existing Architectures

Multiresolutional processing is one of the important features of the reference architectures promulgated by NIST for application in intelligent systems. It is easily recognizable that heterarchies similar to shown in Figure 6 fit within the paradigm of large complex systems including intelligent autonomous robots, unmanned power plants, smart buildings, intelligent transportation systems including large automated bridges. It fits perfectly also to the DOD systems of command, control, communication and intelligence. It is characteristic of heterarchies that while having top-down and bottom-up hierarchical components, they are not hierarchies:

Table of specifications for parameters of multiresolutional planning in DEMOIII [1]

Level	Planning horizon	Replan interval	Reaction latency
1 Servo	50 milliseconds	50 milliseconds	20 milliseconds
2 Primitive	500 milliseconds	50 milliseconds	50 milliseconds
3 Subsystem	5 seconds	500 milliseconds	200 milliseconds
4 Vehicle	50 seconds	5 seconds	500 milliseconds
5 Section	10 minutes	1 minute	2 seconds
6 Platoon	2 hours	10 minutes	5 seconds
7 Battalion	24 hours	2 hours	20 seconds

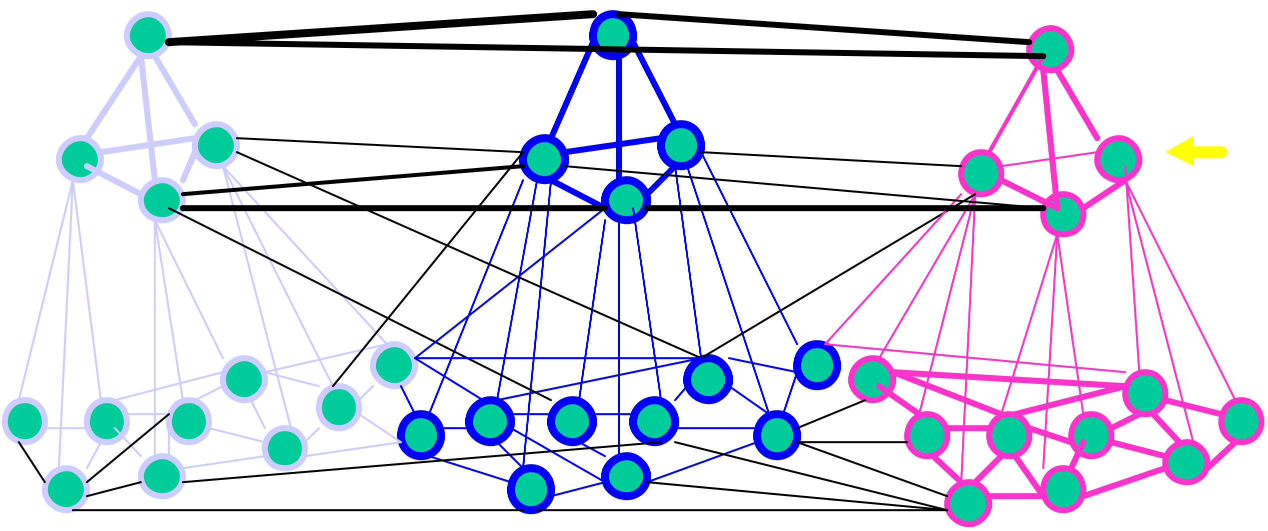

Figure 6. A Community of Interacting Heterarchies

heterarchies are not tree architectures. However, in each heterarchy, a multiplicity of hierarchies can be discovered and employed including heterarchies of Top/Down-Bottom/Up Processing heterarchies of "In-Level" Processing, and others. Similar relationships and transformations are characteristic of Entity-Relational Networks (ERN) that are obtained from semantic networks for using in Knowledge Representation Repositories.

5.3 Kinds of Intelligence

General Intelligence

Many and equally unclear definitions are known from the literature. We refer here to two definitions that seem to be both applicable and instrumental ones.

Definition 1 (Internal)

"An intelligent system has the ability to act appropriately in an uncertain environment, where an appropriate action is that which increase the probability of success, and success is the achievement of behavioral subgoals that support the system's ultimate goal" [9].

Definition 2 (External)

"Intelligence is a property of the system that emerges when the procedures of direct and inverse
generalization (including focusing attention, combinatorial search, and grouping) transform the available information in order to produce the process of successful system functioning." [8].

These definitions should be supplemented by a description of the trade-off to be achieved by any

intelligent systems no matter whether they are oriented a) toward the goal achievement (articulation), b) toward sustaining oneself [realization of self], or c) toward "feeling better" (avoiding paradoxes, antinomies, contradictions). The trade-off is illustrated in the diagram 7.

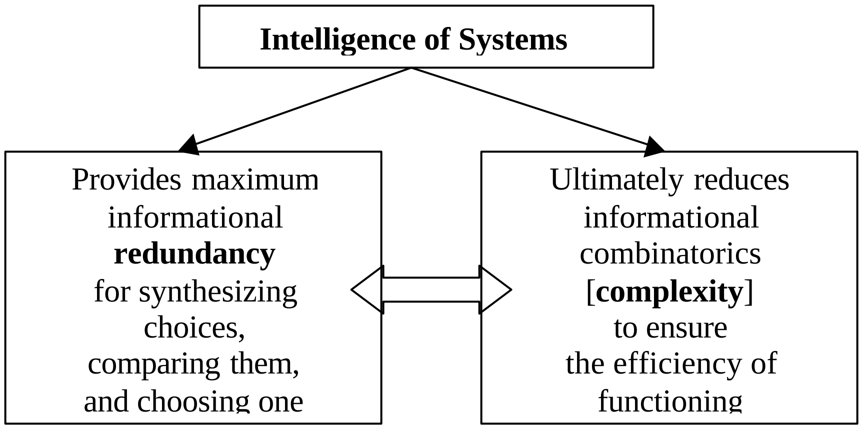

Figure 7. Trade-off achieved by intelligence of systems

Proprioceptive Intelligence

A special kind of intelligence presumes blending the carriers of elements of ELF into an inseparable construction. Proprioceptive intelligence presumes blending sensing devices with actuators of a system. This gives additional properties:

- An ability to modify behavior to maintain feeling comfortable
- An ability to use the working part of a system as a carrier of information

Contemplative Intelligence

All architectures of intelligence considered above are oriented toward pursuing clearly discernible objectives. In some situations this is not the case. The following activities are characteristic for a contemplkative intelligence: it ponders [thoroughly], theorises, cogitates, inquires, ruminates [repetitively], speculates, conjectures, deliberates [in the latter case, the intentionality is a primary issue].

6. Testing the Performance and Intelligence

The general lessons of the existing experience in testing performance of systems can be formulated as follows.

- Performance can be different for IS and non-IS. Breaches in communication that are taken care by human operators in non-IS, are covered by automated sub-systems in IS. However, all expected cases might not be reflected in the pre-programmed menu. Thus, learning is the only way to compensate for the inadequate pre-programming. Nevertheless, the failures in representation are expected to endanger the quality of operation even in the most intelligent systems. Another cause of the inevitable failures is the incomplete or inadequate goal specifications.

- We already discussed the fact that the main advantage of the intelligence is giving the ability to deal with unexpected predicaments. Because of this, the main advantages power that intelligence brings to the system is unspecified (and probably, unspecifiable). It should not be forgotten that many hings are NOT and frequently CANNOT be specified.

6.1 Testing Generic Capabilities of Intelligent Systems

The following capabilities can be checked and statistically validated via experimental testing in a functioning system on-line.

- All terms from the assignment are supposed to be supported by the high resolution, low resolution and associative knowledge.
- Each level must demonstrate its ELF consistency. Standard testing scenario can be constructed and exercised.
- Functioning is presumed the ability to work under incomplete assignment (including incomplete statement of what should be minimized or maximized).

- Functioning should be possible under not totally understandable assignment.
- Functioning should be possible under not totally interpretable situation.

6.2 Skills that can be checked off-line

Off-line testing allows for enabling better preparedness of the system for critical situations.

- Multiple channels of enabling functions (allows working under a condition that a part of the capabilities is disabled).
- The existence of the internal model of the world that is capable of planning and developing "the best" responses to the changing environment and dynamic situation by using simulated system.
- The ability to learn from experience of functioning: learning can be verified prior to the future situations of functioning..
- The ability to judge the richness of the MR ontologies. Indeed, the vocabularies and grammars of all levels allow for shaping and refining them prior to real operation.
- The ability to re-plan and/or adjust plans in important when the original ones are no longer valid; this is another crucial aspect that must be evaluated.

6.3 Understanding "Commander's Intent"

One of the important functions of intelligence is restoring of the *intent* of the node that is the source of the goal. In other words, a system with intelligence ought to have the capability to understand its higher level, i.e. the lower resolution level (where the "supervisor" or "commander" is situated). The incoming "goal" is frequently presented rather as an abstract combination of terms. The system should be capable of supplementing the submitted command with additional information (sometimes, contextual) that helps to generate more specific plans internally. This is almost equivalent to creating the goals for itself: the elements of future autonomy emerge in the intelligent systems as tools of performance improvement.

7. Conducting Disambiguation

We have addressed the need to verify the consistency of statements generated at a level by their compatibility with the adjacent levels above and below. Clearly, they should not violate generalizations creating objects and events of the level above, and the results of decomposition of the entities and events at a level of consideration should not violate consistency of the higher resolution representation and decision making.

The following capabilities are expected from the system of disambiguation.

- 1. Hypotheses should be formulated of generalizations for the upper level and instantiations for the lower level. These hypotheses are obtained by GFACS and $CFACS^{-1}$ within the context of the situation represented by the ELFs of three adjacent level under consideration.
- 2. When the hypotheses generation is completed (a ranked list of hypotheses is constructed) the consistency of the hypotheses should be verified an the i-th, [i+1]-th and [i-1]-th levels. Verification is done by checking whether the closure of each ELF still holds. This operation is an example of creating the "Tarsky's Hierarchy" that should eliminate the possible contradictions that are expected because of Godel's theorem of incompleteness.
- 3. The other hypotheses on the lists should be checked, too. We should observe what is the change in the situation when the hypothesis is changed, are the ELFs closures violated, what is the relative compatibility of other hypotheses to the BG solutions contemplated.

In Figure 8, an example of ambiguous situation is presented. The right alternatives are hypothesized, and the disambiguation is easily performed by the human viewers even not familiar with the original phenomenon (see http://www.ournet.md/~mythorm/LochNess.htm) . One can easily check that the activities for disambiguation performed in a natural way are similar to those presented in the above list (hypothesize the connectivity of all segments of the expected body of a living creature (H1), hypothesize the radius of the "underwater" part (H2), verify the H1 with available information of possible living creatures, verify H2 by comparing it woth the visible radius of the part above the surface of "water", etc.

8. Multiresolutional Metrics

The concept of *value judgement* introduced in [9] and expanded in [1, 2] is expected to be a useful component of the measuring performance of systems, in particular, intelligent systems.

Figure 8. Ceramics “Loch Ness Monster” on a poliched wooden surface

Although this concept seems to be almost trivial, coinciding with the concepts of *cost/reward* applied in one set of research results, and repeating the premises of *utility function* from another set of research results, it has more obscurities than can be allowed for applying this concept in practical cases. In this paper, the issues are listed that should be clarified, properly stated and resolved before using the concept of *value judgment* would be scientifically justified.

We have some light problem with the issues of VALUE and VALUE JUDGMENT. Indeed, value judgment system can evaluate what is good and bad, important and trivial, and can estimate cost, benefit, and risk of potential future actions. However, it is difficult to find objective evaluators. Indeed, scalar evaluators need a tool for assigning weights to various components of VJ. Vector evaluators intend to escape the the need for dealing with the idea of relative importance of the components of the vector. Actually, neither is achieved in practical cases. There

- are many factors of preferences that cannot be easily transformed into physical values or money.
- Preferability that is delivered by emotions is still a subject of discussion. It is unclear how to assign a numerical value to the degree of preferability brought by one’s loyalty. Why does one care that the team of his/her school wins the game even if this game is beyond his/her interest and even simple curiosity?
- Even if the problem of computing the value judgment is resolved at a particular level of resolution, one cannot present any meaningful techniques of consolidating all measures into a single numerical value.
- The previous problem might be considered easier if at least we knew where to cut-off building representations of the next level of resolution from above and from below. These are silly but “fundamental” considerations: the limit of generalization from above is achieved when we stop blurring particular details since it affects the interpretation, the limit of instantiation below is considered to be achieved when we do not know how to make further decomposition of the representation.
- One of the areas containing multiresolutional analysis related results and intuitions is not sufficiently analyzed by scientists in multiresolutional representation and behavior generation: the on-standard analysis [10]. A. Robinson stops decimating space at the indistinguishability zone level (the limit of tessellation from below).

- It is possible to expect that Heisenberg's Uncertainty Principle is not bound by sub-atomic particles and quantum mechanics and can be applied for any level of resolution in the MR structures.

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